L1CaloTrigger: Beyond the TDR

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Hardware Status

- TDR Approval $\rightarrow$ Proceeding with design evaluation by building more realistic prototypes (2001)
- Working towards integration of TPG, RCT, GCT (2001-2002)

Beyond the TDR

- HF granularity question
- Ideas for robustness of τ algorithm
- Evaluation of physics channels not covered in the TDR
- New uses of HF information

TDR Results (Rates)

	e	ee	τ	$\tau\tau$	j	jj	jjj	jjjj
Low $\mathcal{L}$	24	18	95	75	150	115	95	75
High $\mathcal{L}$	35	20	180	110	285	225	125	105
	τe	je	MET	e+MET	j+MET	e(NI)	ee(NI)	ΣET
Low $\mathcal{L}$	80,14	125,14	275	12,175	65,175	NA*	NA*	1000
High $\mathcal{L}$	125,20	165,20	350	18,250	95,250	58	28	1500
	μ	$\mu\mu$	μe	$\mu\tau$	μj	μ+ET	μ+MET	Rate:
Low $\mathcal{L}$	10	3	4,12	4,80	4,80	4,600	4,140	25 kHz
High $\mathcal{L}$	25	8,5	5,32	5,140	5,155	5,800	5,200	25 kHz

Rates at high and low $\mathcal{L}$ for a mock trigger table

- A sample set of thresholds that yield 25 kHz rate
- Final trigger table will be much more involved (TBD)

TDR Results (Physics Efficiencies)

Channel	Low $\mathcal{L}$	High $\mathcal{L}$	Triggers Used
H(200) $\to \tau\tau \to$ hadrons	93%	60%	e1, τ1, j1, e2, τ2, j2
H(500) $\to \tau\tau \to$ hadrons	99%	86%	e1, τ1, j1, e2, τ2, j2
H(170) $\to$ 4 electrons	100%	99%	e1, e2
H(110) $\to$ 2 photons	99%	98%	e1, e2
H(135) $\to \tau\tau \to$ e, hadron	96%	72%	e1, e2, τ1, j1
H(200) $\to \tau\tau \to$ e, hadron	96%	74%	e1, e2, τ1, j1
H(120) $\to$ Invisible (tag jets)	96%	58%	j1, j2, missing ET
H(120) $\to$ ZZ* $\to$ e, e, μ, μ		73%	e1, e2
H(200) $\to$ ZZ $\to$ e, e, jets		95%	e1, e2, j1, j2
tt $\to$ e, X	97%	82%	e1, j1, j2, j3, j4
tt $\to$ e, H+, X1 $\to$ e, τ, X2	94%	76%	e1, j1, j2, j3, j4

Note: e at low $\mathcal{L}$ does not require isolation

Efficiencies at high and low $\mathcal{L}$ with mock trigger table

- Only Higgs physics investigated - other channels to be done
- Final trigger table can have more optimized triggers

HF Granularity

Issue: What is the optimal size of HF towers?

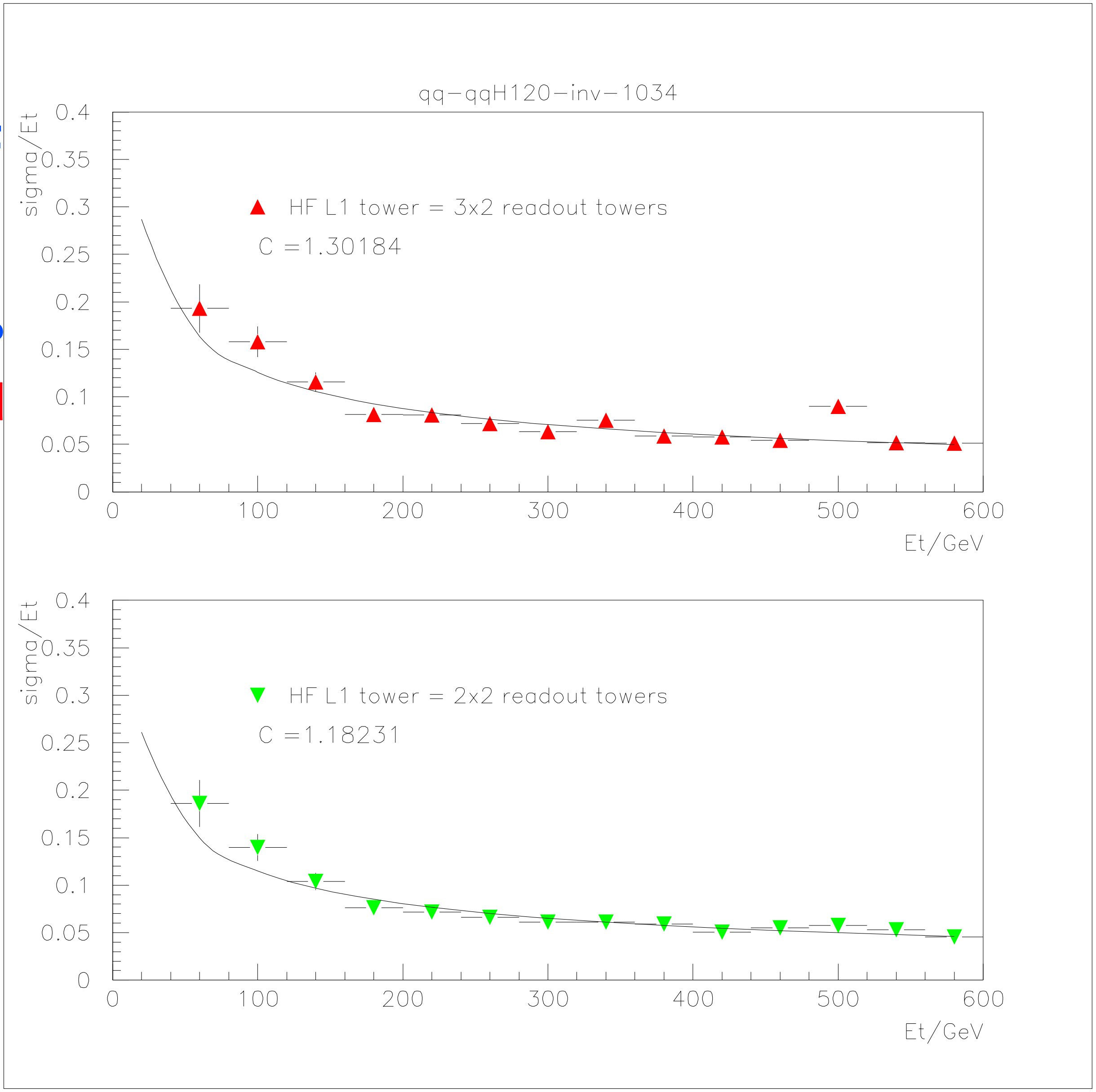
- **Trigger prefers 3ηx2ϕ HF readout to trigger tower mapping**
- **Finer granularity, 2ηx2ϕ?**

TDR simulation results used HF with sums of E rather than E_T for jet and met algo.

- **In reality we expect to use E_T sums**

Jim Brooke's results

- **Fixed to use E_T sums**
- **... show a very slight improvement with finer granularity**



ORCA Production

Simulation production problems in Fall 2000

- **Did not manage to get W, Z and top results for TDR**

ORCA at FNAL and Wisconsin

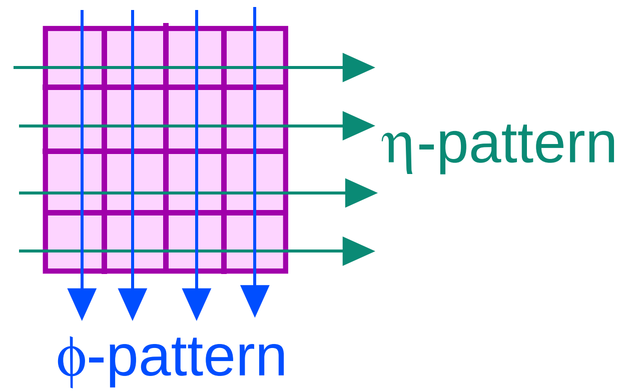
- **Put together our own ORCA production farm**
  - 1.2 TB Objy federation and servers at UW-physics
    - **20 nodes commissioned and more on the way**
  - Access to 600++ CPU farm from UW-Computer Science Condor flock
    - **Some dedicated farm machines**
    - **Many idle CPUs in student labs ...**
    - **Control using Condor software that can stop and restart jobs on available resources**
    - **Adapted ORCA with checkpointing so crashed jobs are restarted from the next event to be processed**
- **Collaborate with FNAL and use their JetMET data**

New τ Pattern Logic

Old algorithm for τ veto bit

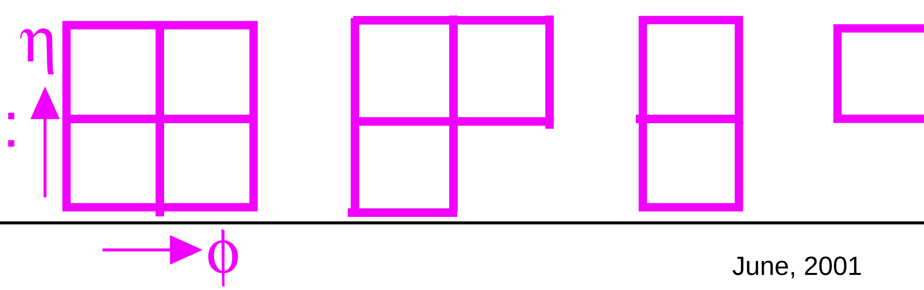
- **Count active towers in EM and HD towers (E_T^{EM},E_T^{HD} > 2,4 GeV) separately and require that there be no more than 2 active towers of each type in a 4x4 region**

New algorithm for τ veto bit



- **Motivation**
  - Reduce susceptibility to noise
  - Additional suppression of normal jet background by vetoing on wide E_T spread
- **Method**
  - Make 4-bit η-pattern and ϕ-pattern projections of active towers - τ E_T deposits should have clustered hits.
  - Veto patterns: 0101,0111,1010,1011,1101,1110,1111
  - Allowed patterns: 0000,0001,0010,0011,0100,0110,1000,1100
- **Coded in ORCA - being evaluated**

Allowed patterns:



Efficiencies for τ algorithm variants

Old (TDR algorithm)

- Counting

Old with 50 GeV cut

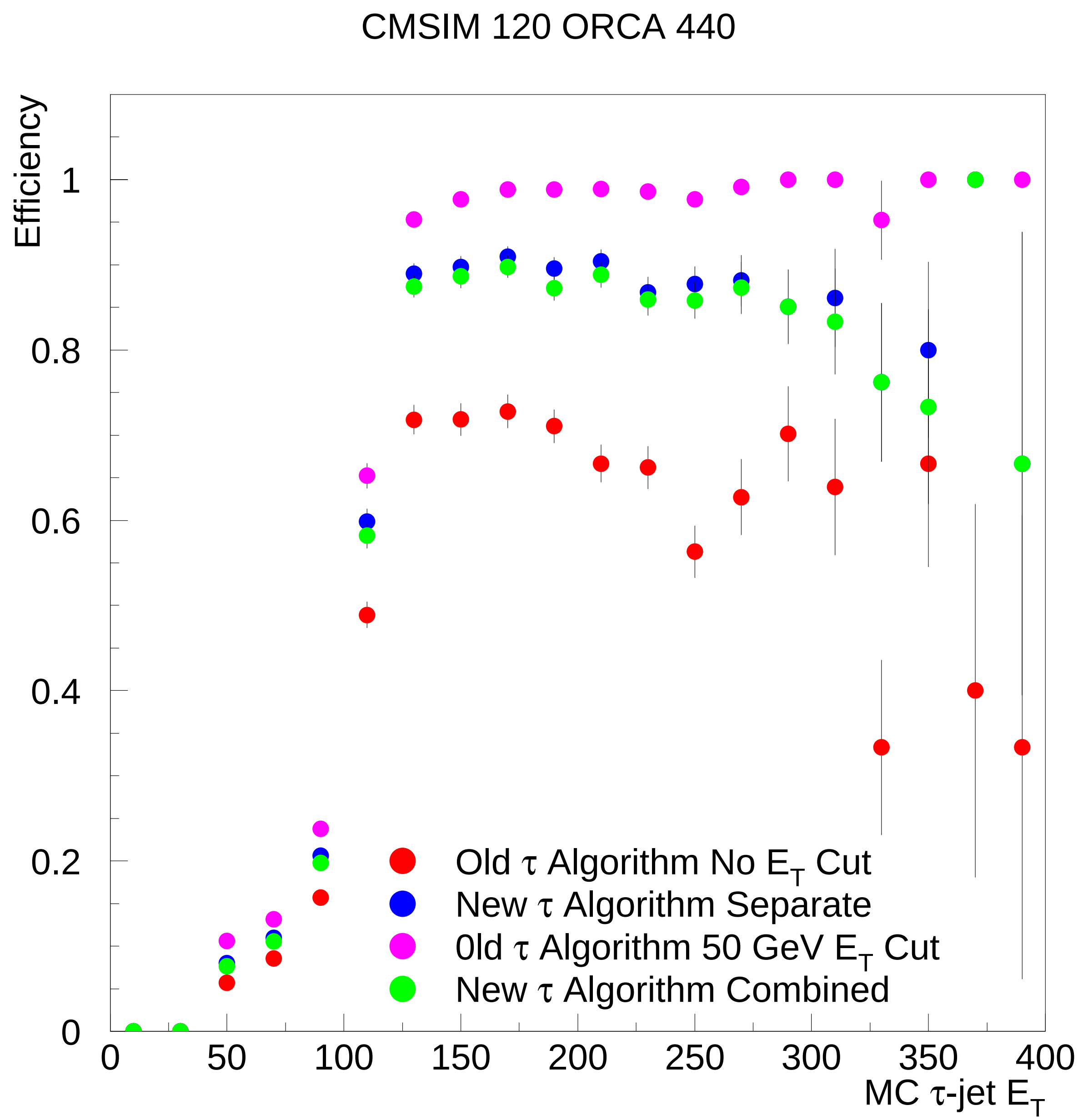
- Counting - ignoring τ bit for E_T>50 GeV

New (Separate)

- Pattern logic on EM and HD towers separately

New (Combined)

- Pattern logic with AND of EM and HD patterns

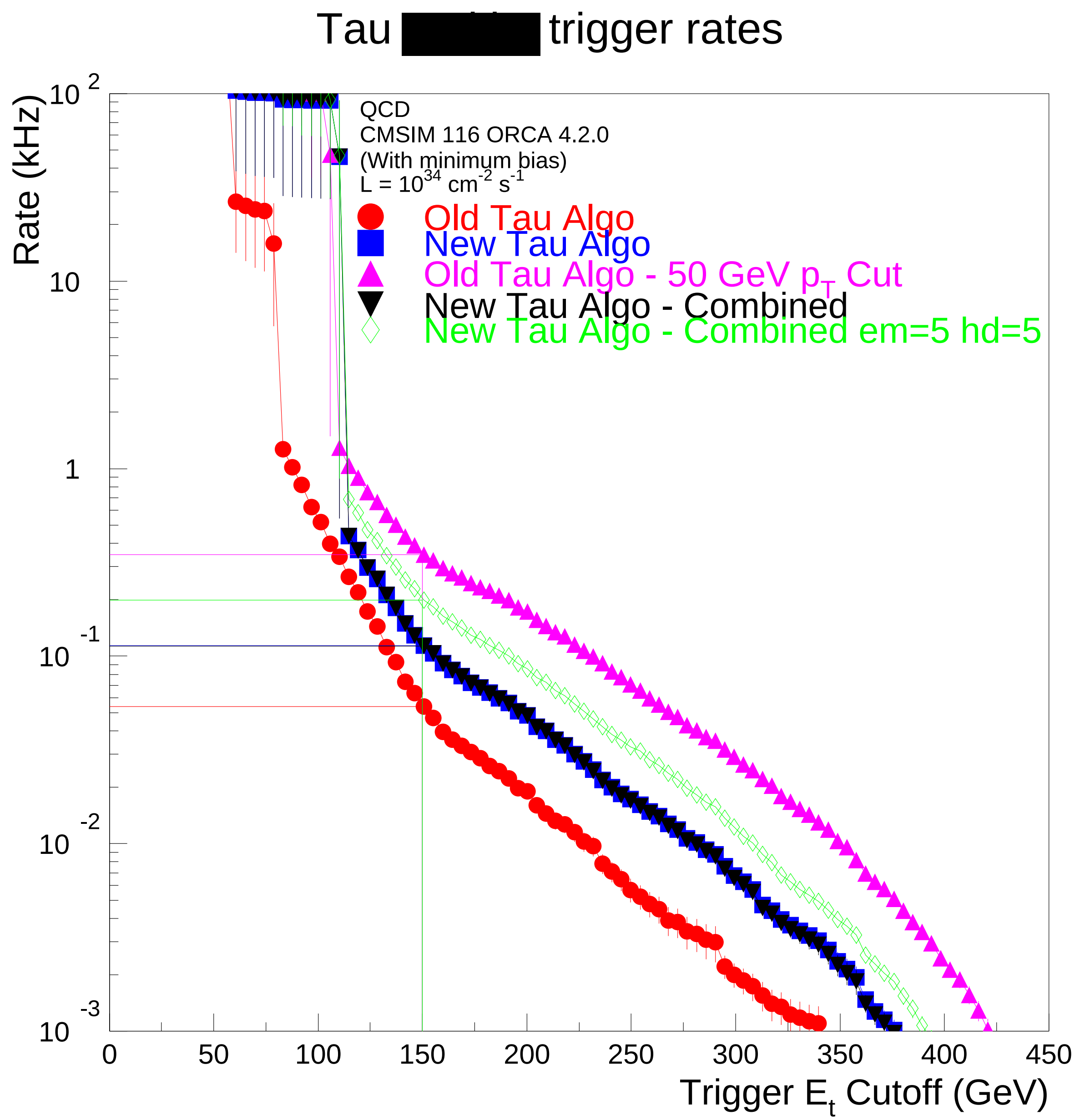


Rates (Preliminary look with partial data)

Not all p_T ranges of QCD data available yet

Use as a guide for relative differences in rates

Absolute values are bogus



Charged Higgs (200 GeV) decays to τ

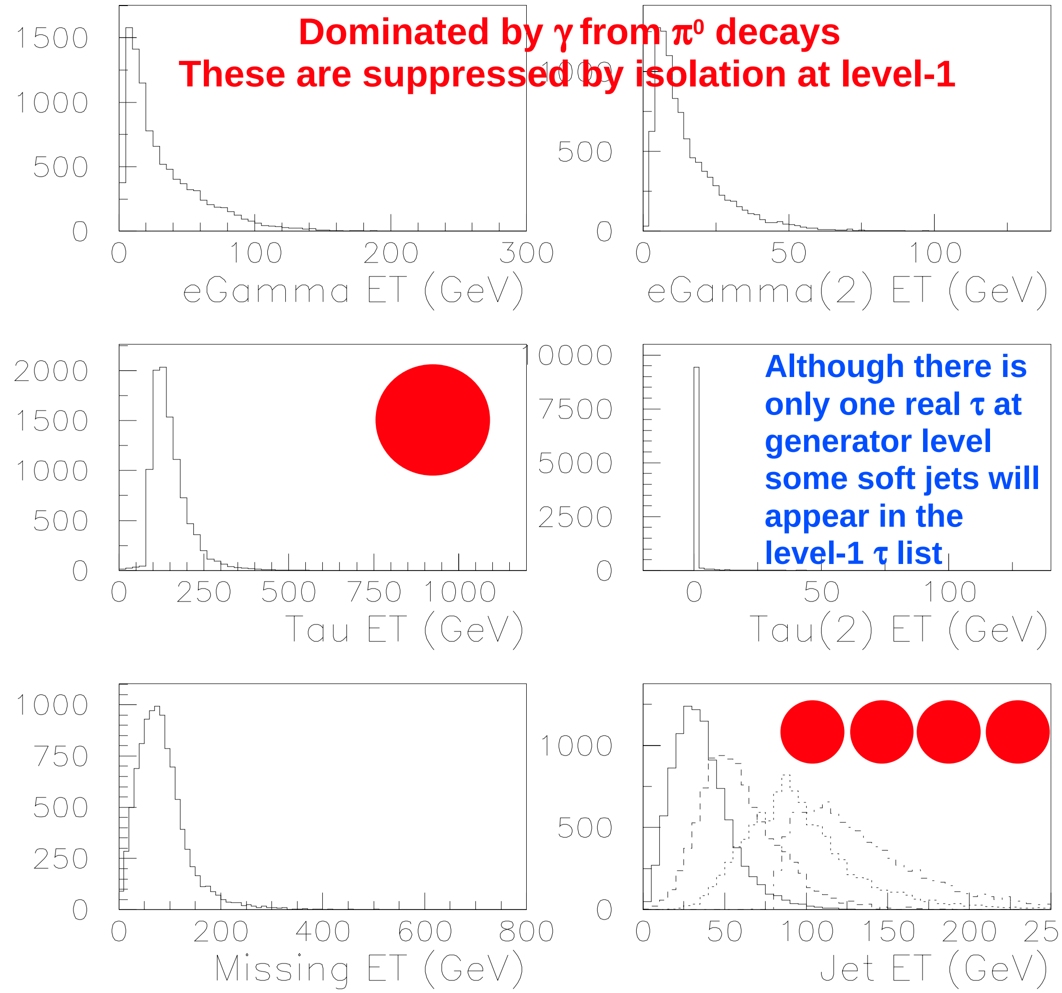
Single τ in decays and multiple jets

Efficiency using only τ trigger: 57%

- **New τ algorithm used**

Efficiency for τ (57%), electron (21%) & jet triggers (41%)

Total = 85%



FNAL ORCA4 Results

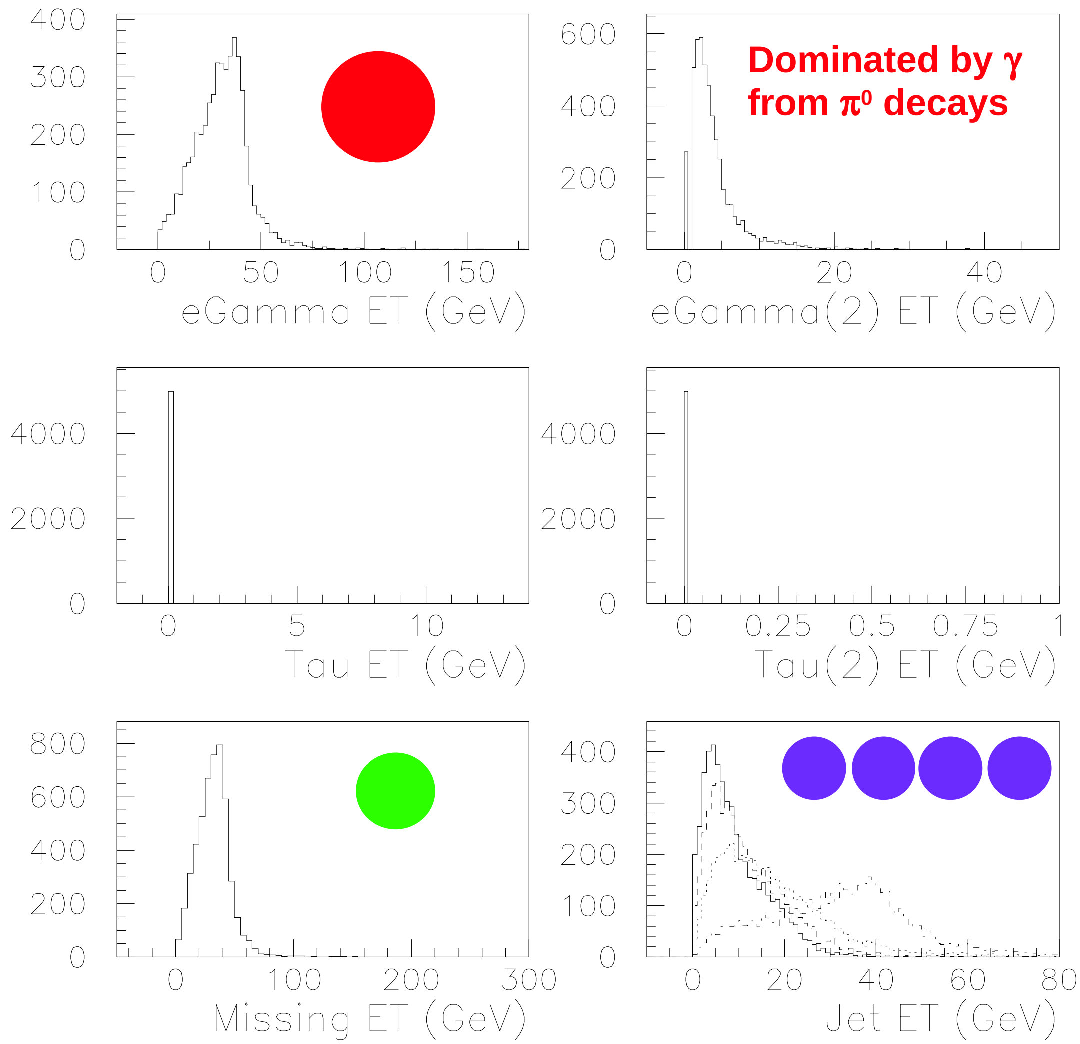
Standard Model: W decay to e^-, X

Single electron threshold (28 GeV) limits efficiency to 47%

- **Isolated electron signature used**
- **Neutrino is too soft to help in trigger**

Improvement possibility

- **Extreme isolation**
- **Use global trigger to demand $\Delta\eta$, $\Delta\phi$ separation from jets**
- **High E_T jet veto + missing E_T**



UW Condor ORCA4 Results

Standard Model: Top decay to e$^-$, X

Single electron trigger efficiency: 66%

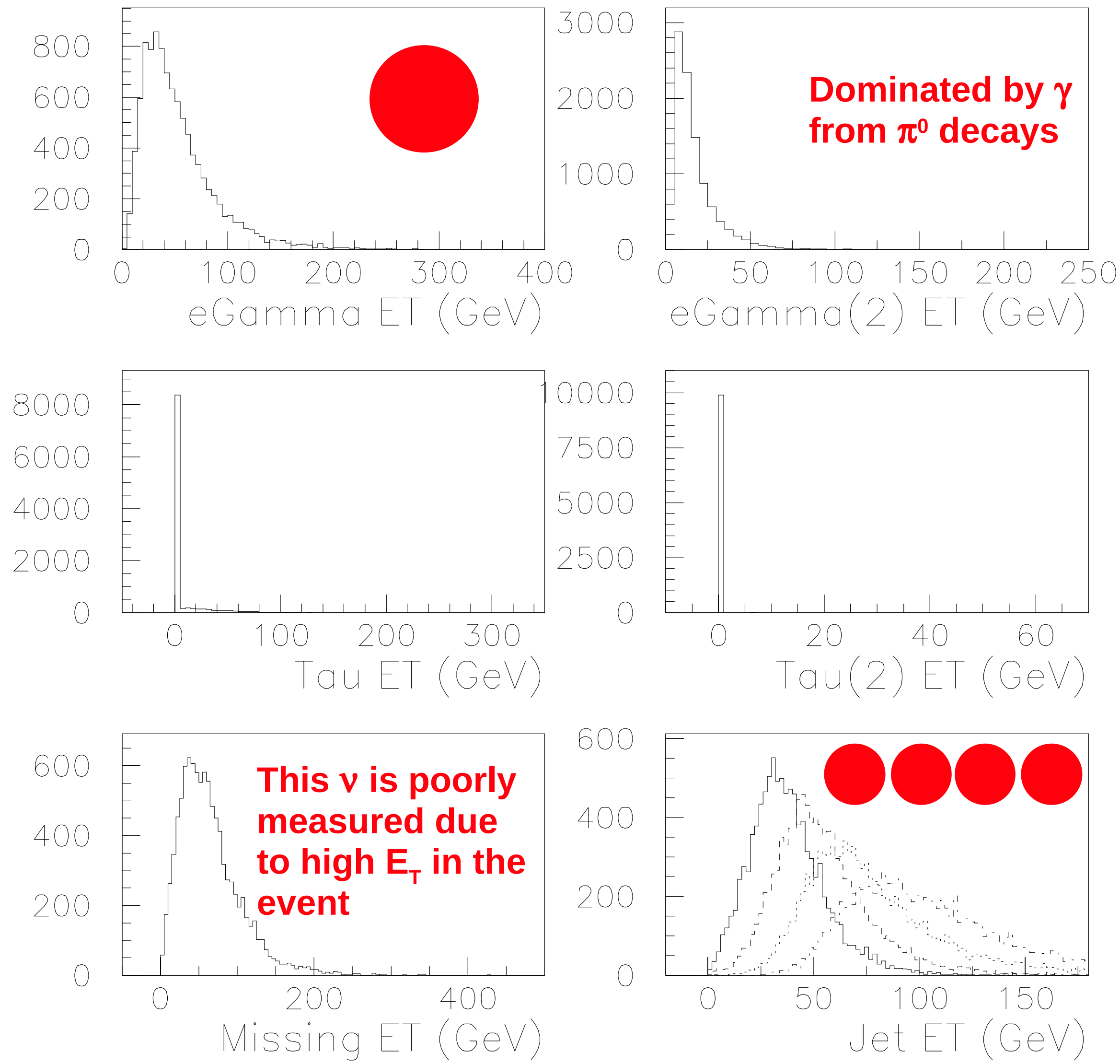
Additional efficiency from jet triggers: 22%

Total efficiency: 83%

Improvement possibility

- **Combined electron + multi-jet trigger**

UW Condor ORCA4 Results



Standard Model: Z decay to e^+, e^-

Single electron trigger efficiency:

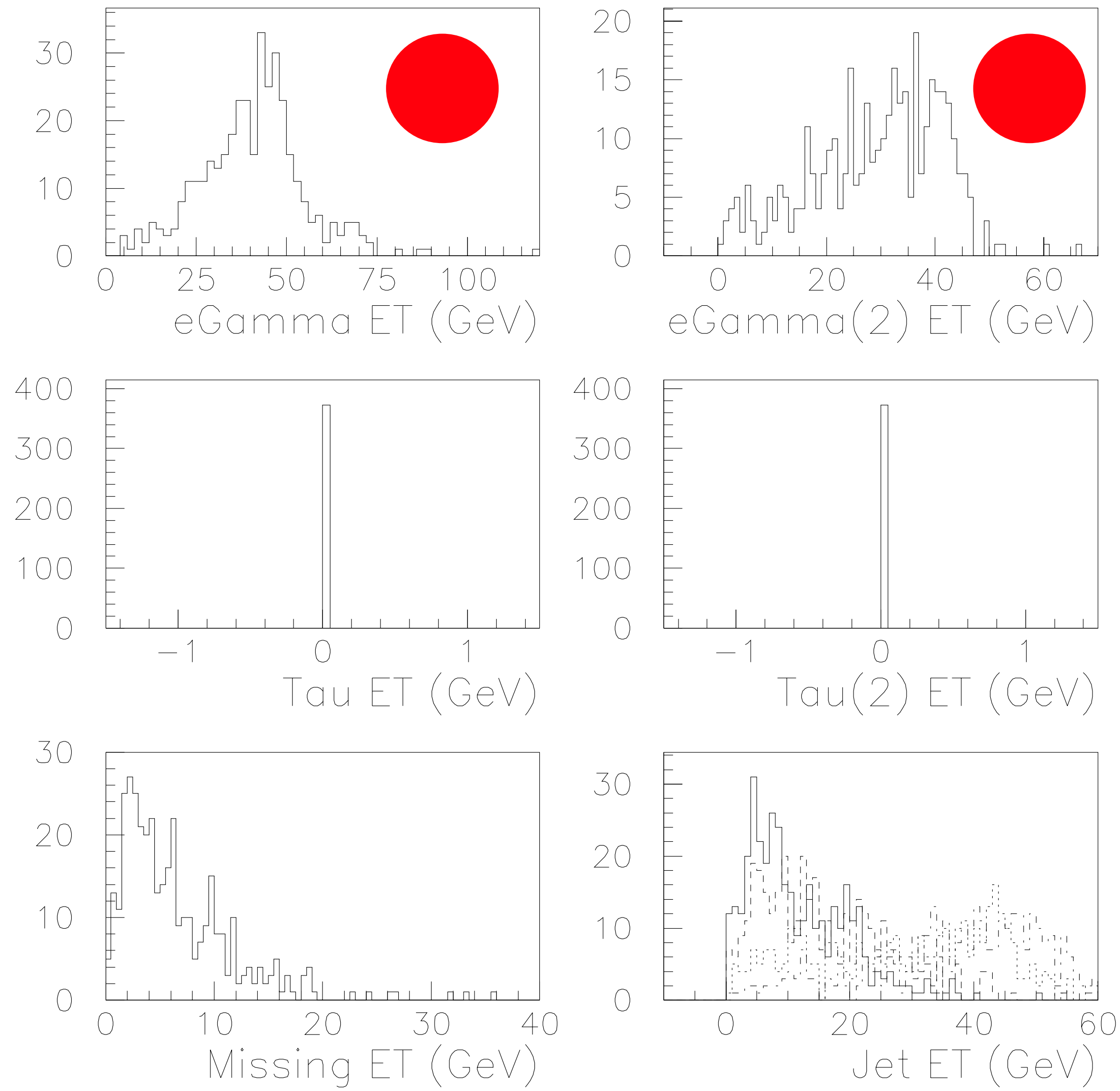
- 77%

Double electron trigger efficiency:

- 72%

Total efficiency:

- 90%



UW Condor ORCA4 Results

qqH (110, 130 GeV) → b b-bar

Signature

- **Two central b jets**
- **Two forward tagging jets in opposite hemispheres**

Trigger Candidates

- **Multi-jet candidates**

Low luminosity efficiency

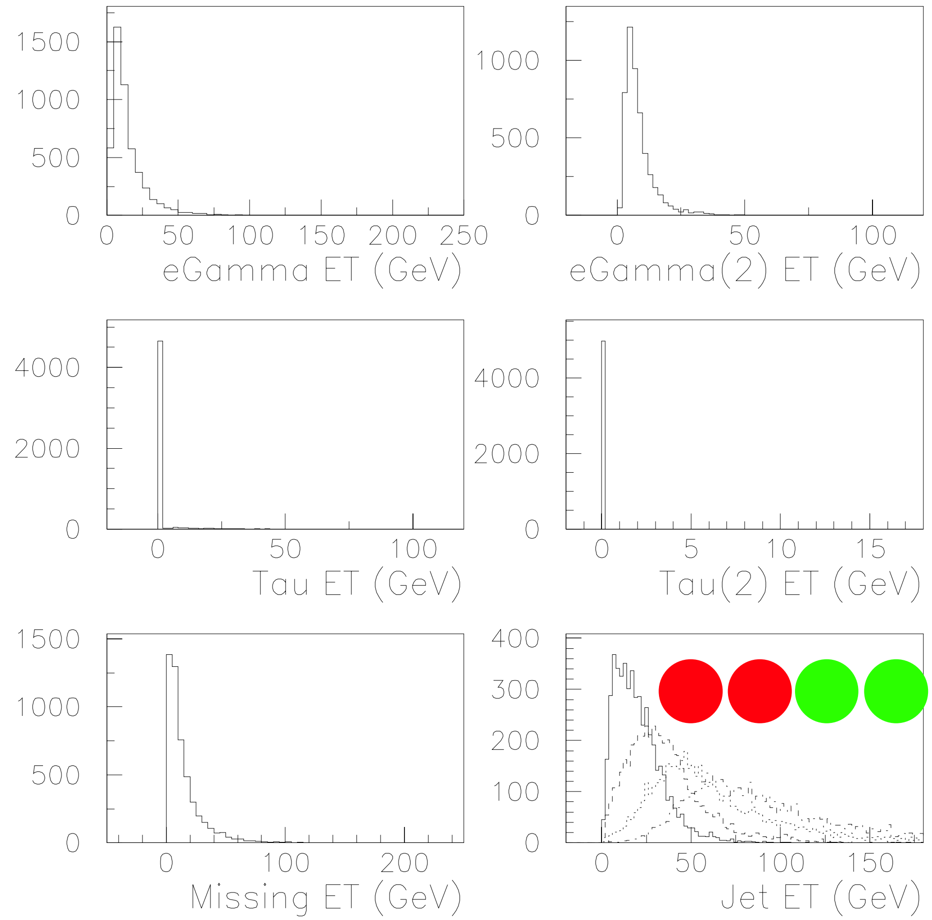
- **M_H = 110 GeV**
  - 83% (jet, τ); 90% (all)
- **M_H = 130 GeV**
  - 84% (jet, τ); 90% (all)

High luminosity efficiency

- **40% - however, this case is difficult to analyse offline**

Improvement to consider

- **Δη between two jets**



FNAL ORCA4 Results

Supersymmetry: MSUGRA

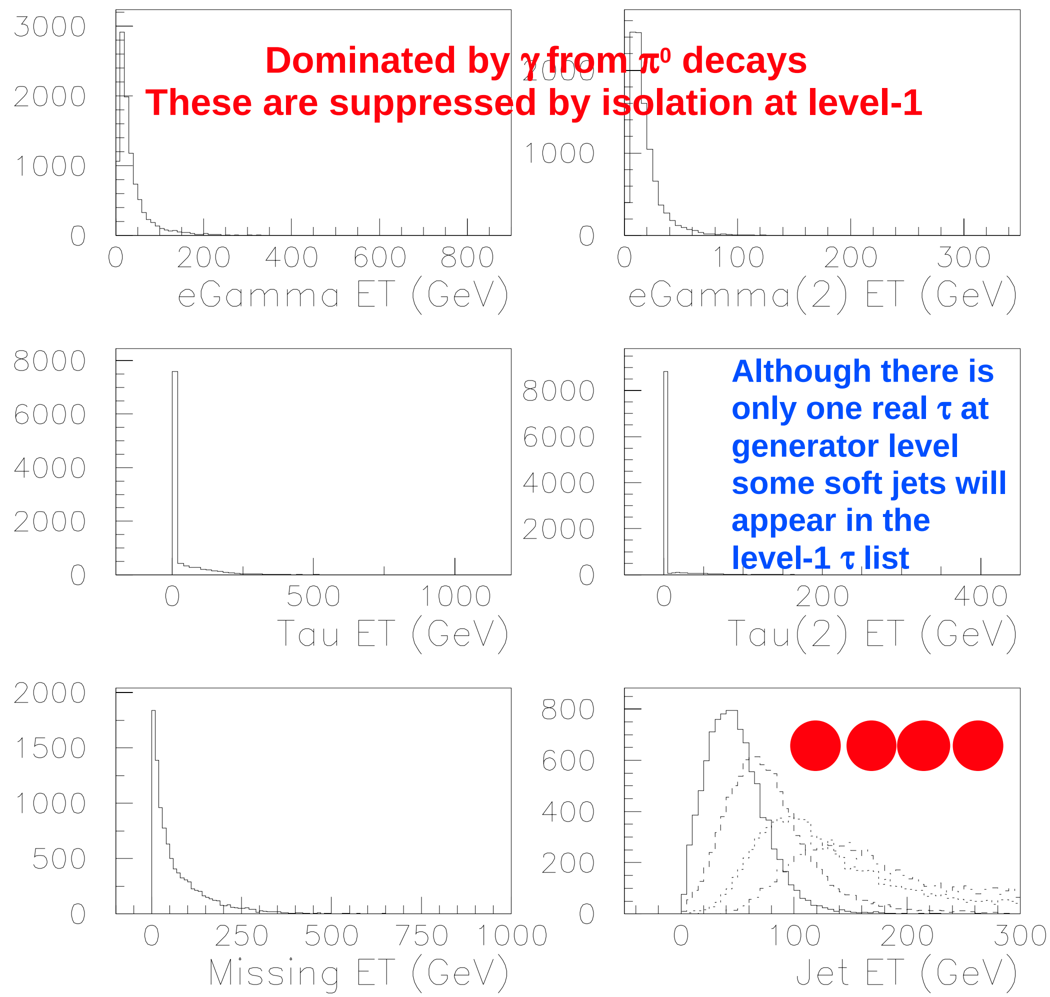
Multi-jet trigger efficiency

- 80%

Soft narrow jets (τ) with lower E_T cuts efficiency

- 68%

Combine to give Total efficiency 90%



FNAL ORCA4 Results

HF Special Uses

RCT Hardware for HF

- **Special receiver crate**
  - Does not need to do 4x4 sums, electron finding, τ logic etc.
    - **A fraction of Receiver card logic**
  - Transmits data to cluster crate
    - **A fraction of Jet/Summary card logic**

Ideas

- **Jim Freeman: Use zero energy HF cell count to track instantaneous luminosity**
- **How do we transfer the data?**
  - Each HF trigger tower is composed of 6 HF physical cells
  - 2 HF trigger towers (8 bit E_T) transmitted on each gigabit link
  - Extra data transfer feasible on current gigabit links (2x9 bits data + 5 bits EDC + 1 bit BC0)
    - **Can use 2x8-bit non-linear E_T and 2x1-bit "zero" data**
    - **Can use 2x7-bit non-linear E_T and 4-bit "zero" cell count**

Summary

Hardware

- **Proceeding according to the plans outlined in the TDR**

Fermilab and Wisconsin ORCA productions

- **Generate and access events on demand.**

New τ veto based on pattern search

- **More robust against noise**
- **Works just as well (H^+ (200 GeV) $\rightarrow \tau\ \nu$ decay efficiency 85%)**
- **Rates are to be evaluated**

ORCA results for physics channels not simulated with ORCA in the TDR

- **Efficiency for inclusive Z(90%), W (48%) and top (83%)**
  - Performs as expected with 30 GeV single electron trigger threshold
  - Ideas for improvements being evaluated
    - **Extreme isolation for W sample.**
    - **Make use of jet activity for top sample**
- **Efficiency for MSUGRA events (90%)**
  - Matches previous studies using CMSIM
- **Efficiency for q q Higgs (110-130 GeV) $\rightarrow$ b b (90%)**
  - Reasonable at low luminosity
  - Expect improvement using $\Delta\eta$ cuts on tag jets